Space Development Matrix: A Novel Concept for Disseminating and Utilizing Planetary Data for the Economic Development of Space

RFI Topic Addressed: **#5** - *What is the highest priority need for integration between PDS data products and either cartographic products, sample material, or data from the Minor Planets Center (or all of them)?*

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Business Data

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The RFI is seeking inputs for organizational, management, interface and dissemination improvements for the Planetary Data System (PDS) as pertaining to an actionable roadmap for 2017 – 2026. Crowd 2 Space Ltd., in conjunction with partner organizations, is developing the Space Development Matrix (SDM), an open source data service platform with the mission to provide holistic economic situational awareness, analysis, oversight and verification as pertaining to the development and sustainability of a Space based economy. In the advent of significant advancements in commercial launch services, the establishment of Space resource extraction and utilization companies, and the legal precedent set forth by the US Congress for the retaining of rights to said resources, Crowd 2 Space Ltd. proposes that NASA considers inclusion of an economic related perspective to planetary/solar system data collection and substantiation as a core capability of the "new" PDS in the next decade. In this RFI response we describe the specific actions required to enable the integration of an "economic" PDS facet along with consequences of not adopting the aforementioned perspective.

1. SDM Introduction

The Space Development Matrix (SDM) is a 1st of its kind relational information creation, network, flow, and aggregation platform that provides the strategic metadata necessary to plan, develop, analyze, verify, and sustain a Space based economy. It was conceptualized to address the following overarching gaps in the current Space economic ecosystem:

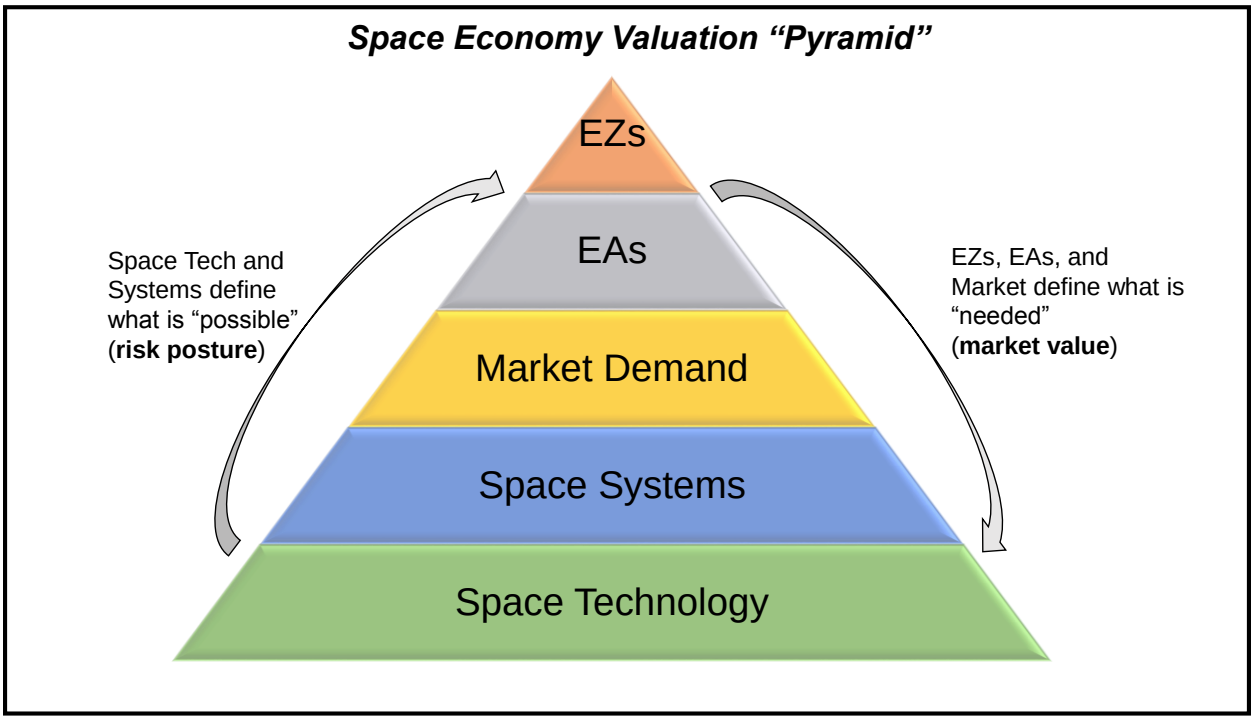
- *Space ecosystem situational awareness* – Global directory on who-is-who and who-is-working / has worked on what / when
- *Technology Development and Mission Prioritization* – Aggregated and real economic demand driven technology and mission prioritization
- *Data Management and Dissemination* – Breaking down data silos and making Space information accessible to as many people as possible via the web
- *The Big Picture* – Aggregation and contextualization of Space technology development milestones, mission accomplishments and planning, and solar system data in an economic centric outlook

The SDM is based on the unique premise of a Space economy centric information classification. We have established the following categories of data classifications in support of the SDM construct:

- **Economic Zones (EZs)** defined as any location, planet, object, orbit or transit trajectory in Space where economic activity is possible i.e. Earth Orbit, Earth-to-Moon transit, lunar surface, Earth-to-Mars transit, Mars, NEA, Asteroid Belt, Jupiter's Moons etc.
- **Economic Activities (EAs)** defined as any activity that results in tangible (financial) and/or intangible (scientific) value i.e. science/research, observation, prospecting, mining, ISRU, fuel depots, in-situ manufacturing, tourism, settlement etc.
- **Market Demand** defined as the aggregation of stakeholder needs in the context of economic activities in economic zones i.e. stakeholders include planetary scientists, government / Space agencies, academia, NGOs, industry, the crowd etc.
- **Systems** defined as standalone economic activity enablers i.e. launch systems, in-space-propulsion, power, communications, life support, habitats etc. (similar to NASA TAs)
- **Technology** defined as technical knowledge that enables Space systems i.e. chemical propulsion, ion propulsion, radiation protection, MEMS, nanotech, photonics etc. (similar to NASA TA-0)

The aforementioned classification categories are integral to the ability to track, analyze and forecast the development of a Space based economy. Aggregated analysis and forecasts will lead to higher confidence valuation of a future Space based economy which will then consequently lead to increases in public and private investments. Space is currently perceived as risky and uncertain business; **our goal is to use technology, system, industry, solar system, and Space activity demand metadata to reduce and/or quantity risk posture as a function of all possible economic activities and zones**. As seen in the figure below, the Space Economy Valuation "Pyramid", market demand constitutes the binding link between technology/system development and the establishment of economic activities and zones. In turn, the establishment of a market is predicated on the existence of economic zones that will drive economic activities and demand. In any economy, the ability to attract capital investments is grounded against the capacity to quantify **risk** and forecasted **market value**. With the creation of the SDM we aspire to provide a platform that aggregates risk and market value for the entire ecosystem. We view the new-PDS as integral

to the creation of substantiated and dependable Economic Zone metadata - planetary, minor body, astromaterial, astrogeology, and not limited to, data and information.



2. RFI Topic and Proposed Roadmap Additions

In this RFI response we are addressing the topic of **"integration between PDS data products and either cartographic products, sample material, or data from the Minor Planets Center (or all)"** (Topic #5). Our recommendations, rationale, and consequences of not adopting are summarized in the table below:

Action ID	Recommendation	Rationale	Consequences of not adopting
1	**Cross-platform** (PDS, Minor Planets Center and other) and **cross-data product** (cartographic, sample etc.) **integration**, **linking**, **indexing** and **traceability**	• Platform and data product integration will enable higher fidelity data dissemination • Easier access to all-inclusive data will increase accessibility and the user community • Linked data will enable detailed substantiated planetary data in the context of traceable economic development	• High fidelity data dissemination and indexing (especially in the context of economic development) will be challenging and costly • Low probability of increased user base and accessibility • No trace to verifiable and addressable economic value
2	**Cross-platform API** (i.e. one API for PDS, Minor Planets Center etc.)	• All-inclusive API retrievals • Streamlined API standards, adjustments and improvements thereof • One source for all planetary data adds credibility to substantiated economic information	• Multiple API retrievals will make integration with data providers more challenging

Action ID	Recommendation	Rationale	Consequences of not adopting
3	Addition of **Economic Zone** and **Economic Activity indexes**	• Economic contextualization of planetary data will enable a holistic analytic approach to the determination/forecasting of a Space based economy	• Utilization of planetary/minor body data in the context of substantiated economic development will be more challenging and less credible
4	Addition of **"data confidence" metrics** to all planetary, minor body and other data products	• Scientifically determined prospecting data confidence levels (i.e. accuracy, resolution, probability etc.) will increase confidence in industry's addressable market projections	• Unquantifiable confidence in data will result in industry speculation on resources which in turn will result in less private and public investments in the economic development of Space

The following use case examples explore how PDS data would be utilized by the SDM with and without the aforementioned changes (as shown in the above table).

With implemented recommendations – The SDM platform would use one API call on a periodic basis to pull all-inclusive data that provide the following intra-linked and traceable insights:

- Astrometric observations on all planets and minor bodies as related to economic zone boundary definitions which in turn determine the detailed economics of transit to/from said economic zone vs. time
- Astromaterial information as related to planetary and minor body high fidelity resource decomposition which in turn provide a vetted quantification on the physical value of resources and the ability to assay true economic value
- Detailed geological surveys and map information as a function of resources and topology which in turn provide a vetted quantitation on the addressable value of economic zones and activities

Without implemented recommendations – The SDM platform would use at least three (most likely more) custom API calls on a periodic basis to pull the three aforementioned sets of data. The SDM team would semi-manually index and classify the data in the context of EZs and EAs. Verifiable data linkage and traces would be near impossible. Credibility of the aggregated data in the context of economic development would be questionable and highly contingent on human error in data handling/manipulation and vetting.

3. Summary

Crowd 2 Space Ltd. (www.crowd2space.com) has one goal: to make Space accessible to as many people as possible and to help facilitate the development of a true Space based economy. We are working with the Earthlight Foundation and the New Worlds Institute (501 (c) (3) non-profit organizations) to develop the Space Development Matrix as an open and free resource to the entire Space community and the public.

In the context of this RFI we are proposing that NASA considers the following simple yet extremely crucial recommendations for the augmentation of PDS capabilities in the context of the economic development of Space:

1. **Initiation of cross-platform and cross-product integration, linking, indexing and traceability**
2. **Creation of one all-inclusive API**
3. **Addition of Economic Zone and Economic Activity indexes**
4. **Addition of data confidence level metrics**

We are developing the SDM with private investment and donations, and aspiring to launch a beta version by May 2016.

The Crowd 2 Space Ltd. team would welcome the opportunity to discuss or further articulate any of the aforementioned recommendations, and to also discuss any possible future collaboration with the NASA PDS team.

About the Author

Jason Aspiotis is a Gen Y Space exploration and settlement strategist. He is the Founder, CEO and CTO of Crowd 2 Space International, a start-up developing novel strategic financing, crowdsourcing and crowdvetting solutions for Space tech, exploration, economic development, tourism and settlement. He was formerly a Chief Engineer at Raytheon with 13+ years total experience in R&D, systems engineering, product design/management, and business development for space and airborne products in passive and active imaging, advanced electro-optical, High Energy Laser, and laser communications systems. Prior to Raytheon, Jason managed the manufacturing of commercial products and participated in university level R&D in lasers, plasma physics and space payloads. In 2015 Jason joined the New Worlds Institute and the Earthlight Foundation as Director of the Space Development Matrix project. Jason has a BS in Astronomy/Astrophysics/Physics from the Florida Institute of Technology, a MS in Physics from the University of Central Florida, and a MS in Engineering Management from the University of Southern California.